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Cross-layer Design of an Asymmetric Loadpower Control Protocol in Ad hoc Networks

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Abstract— **Cross-layer design is important in wireless ad hoc network and the power control methods. Power control is the intelligent selection of transmit power in a communication to achieve the better performance within the system. Cross-layer is used to sharing the information between the layers. CLD using LOADPOWER (LOADPOW) control protocol is reduce the overall end-end delay in transmission power. So many power control schemes are dealt in network layer but this work Power control protocol was done in MAC layer and it plays a vital role. A MAC approach to power control only does a local optimization whereas network layer is capable of a global optimization. Simulation was done in NS-2 simulator with the performance metrics as throughput, and energy consumption and end-end delay. The key concept is to improve the throughput, saves energy by sending all the packets with optimal transmit power according to the network load, transmission power was given, when the network load is low, higher transmission power gives lower end-end delay and vice-versa.**

Index Terms— **Cross-layer design, MAC, LOADPOWER.**

I. Introduction

An ad hoc network is a set of nodes that have the ability to communicate wirelessly without the existence of any fixed infrastructure. Nodes in an ad hoc network use other nodes as intermediate relays to transmit packets to their destinations. Since nodes are usually battery operated, energy conservation is an important issue. Furthermore, because of the broadcast nature of the wireless medium, ad hoc networks are also limited by interference/capacity considerations. CLD is used to sharing the information between the layers. The network is ad hoc because it does not rely on a preexisting infrastructure, such as routers in wired networks or access points in managed (infrastructure) wireless networks. Instead, each node participates in routing by forwarding data for other nodes, and so the determination of which nodes forward data is made dynamically based on the network connectivity.

Some of the challenges involved in the creation of an adhoc network are:

1. Routing challenges: routing in a dynamically Changing environment
2. Wireless medium challenges: lower bandwidth, higher error rates, frequent disconnections and Less security compared to fiber carriers;
3. Portability challenges: lower power and smaller storage capacity compared to desktop computers.

A. *Power Control*

Power control is intelligent selection of transmit power in a communication system to achieve good performance within the system. Optimizing metrics such as a link rate, network capacity, coverage range and the life time of the network. Without a central node to administer power control, improving network topology with energy efficient communication is more challenging in ad hoc wireless networks. Further, if the ad hoc network is large consisting of thousands of nodes, collecting information from all the nodes and passing it to the concerned nodes lead to high overheads. Thus, distributed topology control algorithms that are asynchronous, scalable and localized are particularly attractive for ad hoc networks.[1] The power control in ad hoc networks determines the quality of Physical layer link. MAC layer bandwidth and degree of spatial reuse, while at the same time affects the network layer routing, transport layer congestion control and QOS of application layer, etc. [4-11].

An ad hoc network typically refers to any set of networks where all devices have equal status on a network and are free to associate with any other ad hoc network devices in link range. Very often, ad hoc network refers to a mode of operation of IEEE 802.11 wireless networks. Power management in ad hoc networks is a more difficult problem for two reasons. First, in ad hoc networks, a node can be both a data source/ sink and a router that forwards data for other nodes and participates in high-level routing and control protocols. A major challenge to the design of a power management framework for ad hoc networks is that energy conservation usually comes at the cost of degraded performance such as lower throughput or longer delay. A naive solution that only considers power savings at individual nodes may turn out to be detrimental to the operation of the whole network.[1]. A wireless node in an ad-hoc network has limited battery power supplies. Therefore, it is important to reduce its energy consumption. A wireless node has four modes: transmit, receive, idle, and doze[3].

B. *Cross-layer design definition*

To fully optimize wireless broadband networks both the challenging from the physical medium and the Qos-demands from the applications have to be taken into account. Rate, power and coding at the physical layer can be adapted to meet the requirements of the application given the current channel and network conditions. Knowledge has to be shared

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between all layers to obtain the highest possibly adaptivity.

Cross-Layer Design (CLD) is a new paradigm for network architecture that allows making better use of network resources by optimizing across the boundaries of traditional network layers. This proposed Cross-layer with LOADPOWER control protocol improves the network lifetime along with the total-energy consumption.

C. *Motivations for Cross-Layer Design*

Cross-layer optimization deûnes a general concept of communication between layers, considering certain smart interactions between them, and resulting in network performance improvements. It aims in coupling the functionality of network layers with the goal of boosting system-wide performance[4]. Traditional approach concerning OSI layered model can recognize a subset of possible cross-layer interactions depicted in Fig 1.

In Fig. 1, Cross-layer or interlayer networking can be considered as one in which different layers of the network protocol stack inter-communicate the useful information so as to collectively achieve the desired vertical optimization goal. For the sake of QoS (quality of service) requirements varying with applications, the network or higher layers function should directly base on the information from the lower physical and MAC layers [2]

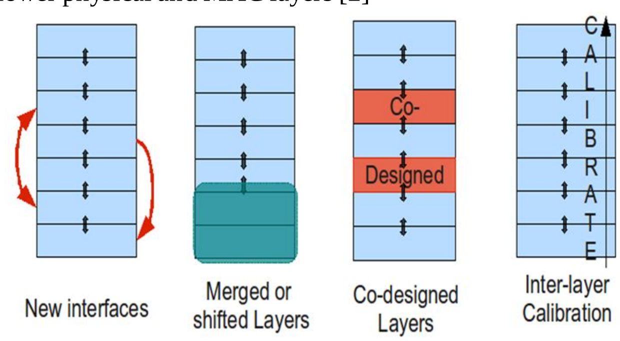

Figure 1. Creation of Cross-layer design

Steps

1. First the new interfaces are created in the protocol stack.
2. Merging of these layers is done.
3. Merged layers are designed in the stack.
4. Inter-layer communication takes place using the shared information in the protocol stack.

Design

1. There exists the direct coupling between the physical and the upper layer.
2. In Cross-layer design, only to meet the fast growing demands.
3. Cross-layer design required to integrate all the layers.

Cross-layer design is not a non-layered or single-layered design.

D. *Necessity for Cross-Layer*

System energy consumption is affected by all layers. On the other hand, all layers should co-operate to reduce overall system energy consumption. Cross-layer design is a way to make such co-operation possible.

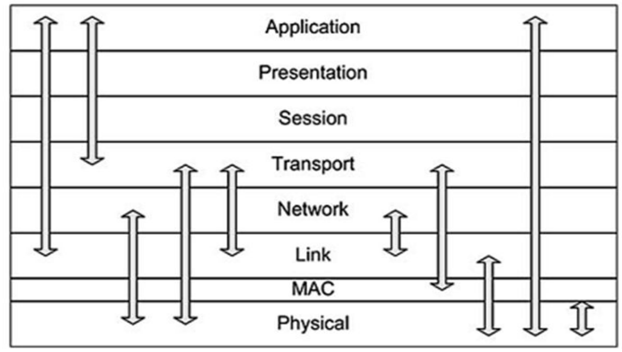

Figure 2. Cross-layer design (Possible inter-layer communication)

In Fig. 2, It blurs the line between layers and leads the optimization of cross layer functionalities. Currently ad hoc routing protocols work mainly on the network layer. It guarantees the independency of the network layer. However each layer needs to do redundant processing and unnecessary packet exchange to get information that is easily available to other layers [8][9]. This increases control signals resulting in wastage of bandwidth, packet collision, etc. By using interlayer interaction, different layers can share locally available information. This will result in substantial amount of performance improvement. In Fig. 2, shows the possible interaction between the cross-layer designs.

In this paper chapter II-A deals with the MTPR and chapter II-B deals with MINPOW protocol power control. The LOADPOWER control protocol shows the minimum power control with lower end-end delay. Implementation was done in NS-2 simulator.

II. Related Work

A. *Minimum Total Transmission Power Routing (MTPR)*

It uses a simple energy metric representing the total energy consumed along a route. Formally, consider a generic route $R_d = N_0, N_1, \ldots, N_d$, where N_0 is the source node, N_d is the destination node, and $T(N_i, N_j)$ denotes the energy consumed when transmitting over the hop (N_i, N_j), the total transmission power P of the route R_d is calculated as per (1).

$$P(Rd) = \sum_{i=0}^{d-1} T(N_i, N_{i+1}) \qquad (1)$$

The optimal route R_o must have the minimum total transmission power as per (2).

$$P(R_o) = \min_{R_i \in R^*} P(R_i) \qquad (2)$$

Where R* is the set of all possible routes. Although MTPR can reduce the total transmission power consumed per packet. In order to maximize the network lifetime, we need to maximize the minimum lifetime for all nodes in the network. Furthermore, we need to consider the flow conservation separately applied to each commodity [12].

B. *Minpow Protocol*

Energy consumption is however also an important metrics, the network capacity and energy consumption are not

optimized simultaneously for current off the-shelf wireless cards. It proactively sends the transmit power levels available, all of them containing the same sequence number of the corresponding minimum power level. Three components PTxelec and PRxelec are known locally to the transmitter and receiver respectively, while PTxRad (p) can be calculated if the smallest transmit power Pi required to traverse a link l can be estimated. Each node takes its own power leveling Fig 3.

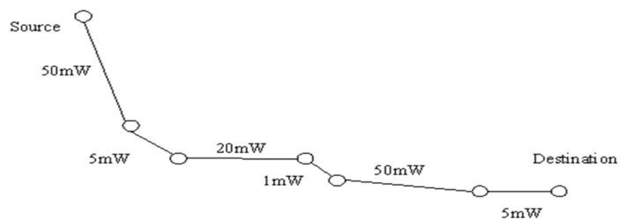

Figure 3. MINPOW diagram

Properties

i) It provides a globally optimal solution with respect to total power consumption. This may not be the optimal solution for network capacity; the two objectives are not simultaneously satisfiable.

ii) MINPOW provides loop free routes. This is true because the distributed Bellman-Ford algorithm with sequence numbers is loop free for non-negative link cost.

iii) No location information or measurement support from the physical layer is needed.

iv) The architecture works for both proactive, as well as Reactive routing protocols.

In this Minpow protocol each node chooses the power level. So the power control is reduced when the each node choosing its own power level[5].

III. Load Power Control Protocol

A. *Load Power Control Protocol*

LOADPOWER control is the proposed power control protocol in wireless ad hoc networks. It reduces overall end-end delay by using higher power when the network load is low and the lower power when the network load is high.

Every transmission causes interference in the surrounding area. Successful reception of packets is possible only if this interference is within some limits. Thus, interference is a key feature of the wireless medium and fundamentally affects the traffic carrying capability of the wireless network. One of the effective mechanisms of controlling this interference is by controlling the transmission power.

Transmit power also affects the important metric of energy consumption. In addition, the assumption of fixed power levels is so ingrained into the design of many protocols in the OSI stack that changing the power levels results in their malfunctioning. Changing power levels can create uni-directional links, which can happen when a node i's power level is high enough for a node j to hear it, but not vice-versa [3].

LOADPOW power control protocol which adapts the transmit power according to the network load. It opportunistically uses a higher transmit power level whenever the network load is low, and lowers the transmit power as the load increases. The LOADPOW algorithm attempts to avoid interference with ongoing traffic by making each node refrain from using a transmit power that would interfere with an ongoing communication in the neighborhood. This can be realized by modifying IEEE 802.11's notion of network allocation vector (NAV).

We propose NAV mechanism so that every node, say a, also dynamically keeps track if the list of current nodes, *busy list*, which cause it to remain silent, i.e., nodes which are currently participating in transmissions which interfere with a. The forwarding decision for a packet is made by the MAC just before transmitting the packet, by making a call to the LOADPOW agent which is the routing agent on the node. For each node bi in the *busy list*, the LOADPOW agent finds, by looking in the various routing tables, the highest power level at which b is not reachable, i.e., which does not interfere with b. The min of this power level over all elements in the *busy list* gives the *safe power level* for a. It denotes the power level at which a can transmit without "disturbing" any ongoing communication. Forwarding is done by consulting the routing table corresponding to *safe power.*

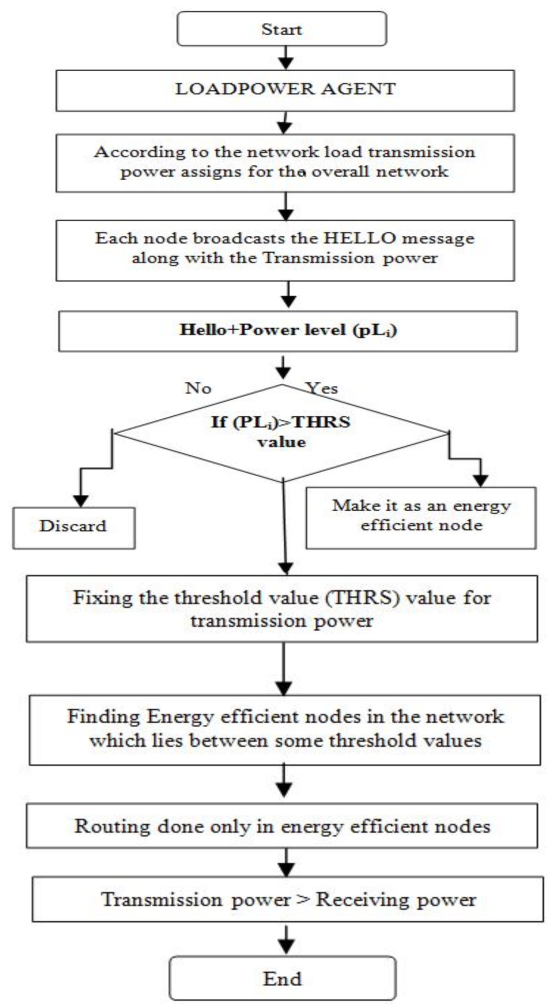

Figure 4. Overall Flowchart for LOADPOW Protocol

Fig. 4, shows the overall flowchart for LOADPOW protocol. LOADPOW agent is running in the network layer and then the transmission starts.

Steps:

1. According to the network load, the transmission power assigns for the overall network.
2. First the source node sends the beacon messages to all the nodes.
3. The node has the header:

Packet id	Power level(PL_i)

4. Hello messages along with power level are distributed to the network.
5. Threshold value (THRS) range is dynamic for nodes, which are under transmission.
6. If the THRS>PL_i, then the nodes selects the energy efficient nodes.
7. Energy efficient nodes are lying between the dynamic threshold values.
8. Then the routing had done only in the energy efficient nodes.
9. According to this, the overall transmission power is more than the receiving power in the network. So it reduces the end-end delay.

From the perspective of a node, when the network load is low, the medium around it will be busy less often and it shall be able to use a higher transmit power more of the time. As the load increases, there will be on average more communications nearby, and the node will use a lower power so that it does not interfere with those communications. Note that our protocol involves cross-layer interaction between the MAC and the network layer. It is based on the multiple routing table architecture presented earlier but does not rely on channel estimation or position information. It should be noted that LOADPOW may have temporary routing loops, since at each hop a different power level routing table may be consulted. But if the network load reduces the packets should reach their destination comfortably. The temporary loops may be a generic issue with any opportunistic, distributed load based protocol.

A second issue is related to practical implementation. We have assumed that the MAC can make a function call to the forwarding functionality, possibly through a call back function pointer which is put in the packet when forwarding. Similarly a call to the ARP cache may also be needed. This may be difficult to do in a real operating system. Another subtlety is that the forwarding decision is actually made before sending the RTS, so that the RTS can be sent to the next-hop which has been decided by the LOADPOW agent. However the DATA packet is sent only after the CTS is received. The busy list could change in the meantime and possibly invalidate our forwarding decision. However, it can change only for the better, i.e., the safe power level can only increase because all nodes who hear the RTS are required to remain silent for a duration which allows the CTS reply to be received.

B. Independent Power in LOADPOW

Because of the inherent overheads involved in global coordination, it is desirable for the ideal power control scheme to support distributed coordination among nodes. IPC allows each node to use its own transmission power. However, because two neighboring nodes may use different transmission powers, some links will becomes asymmetric unlike in conventional ad hoc networks. While several recently proposed protocols tackle the presence of asymmetric links at the routing layer, the possibility of wide-spread proliferation of asymmetric links will also necessitate changes at the MAC layer.

C. Extending IEEE 802.11 for asymmetric links

For our simulation AODV routing protocol has been considered because of its symmetric nature of routes. In the conventional IEEE 802.11 MAC, a sender transmits an RTS, and DATA packets to a receiver, and the receiver responds with CTS and ACK packets to the sender. Because the MAC layer uses the same power for all packets, asymmetric links will induce link failures. If the receiver, however, uses the power notified by the sender (say piggybacked on the RTS packet) to transmit CTS and ACK packets, asymmetric links can be supported successfully.

D. Asymmetric Routes

Although advanced routing schemes such as ODMRP, WRP could potentially be used to use symmetric routes, such mechanisms are not considered in this work. For our simulations, restrict the route selection process to choose only asymmetric routes by sending back AODV route-replies along the route the route-request traversed through the source and destination.

E. Heterogeneous power in MAC

MAC layer protocols for wireless ad hoc networks typically assume that the network is homogeneous with respect to the transmit power capability of individual nodes in the network. The IEEE 802.11 MAC protocol has been popular for use in ad hoc networks. To investigate the performance of this protocol when it is used in a network with nodes that transmits at various power levels. We show that overall throughput is lower than the throughput of a network in which all nodes transmit at identical power levels. In addition, low power nodes have a disadvantage in accessing the medium due to higher levels of interference from the high power nodes.

From the Fig. 5, it can be observed that (i) for the lightly loaded scenario, the maximum throughput (per-flow) is achieved at the low transmission range of 300m, in light loaded, and throughput is minimum because lower transmission power is given for the network. (ii) for the moderately loaded scenario, the maximum throughput (again per-flow) is achieved at a transmission range of approximately 800m, and (iii) for the heavily loaded scenario, the utilization is poor and the maximum throughput is achieved approximately at 1000m because transmission power is higher and so nodes uses the higher transmission power for transmission.

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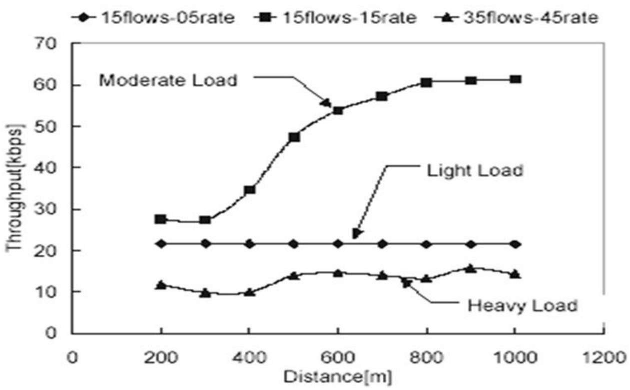

Figure 5. Throughput for various Loads

F. Network Load

Network Load is defined as that, how many nodes that are currently available in the network. Based on that network load is calculated. Due to mobility, nodes move with random. According to that network load could be calculated.

Because this is an unmanaged, decentralized system:

- Devices are not distributed across the space evenly
- No one device can be guaranteed to hear all other devices
- No one device can be trusted to calculate fairly for all devices
- All devices must calculate load for their particular space and situation

This protocols deal with two scenarios, when the network load is high, lower transmission power gives lower end-end delay. When the network load is low, higher transmission power gives higher end-end delay. The transmission takes place only the nodes having more energy efficiency. So the transmitted power is low, when compared with the received power in the network.

G. Calculation of Energy Efficiency in the network

Calculating the network load depending upon the size of the network. When the nodes in the network changes, according to the network load transmission power could be changed. In the network, which nodes having more battery life, TTL value. Those nodes are taken as energy efficiency nodes.

H. Example

Consider the network with the total number of 10 nodes.

1. Calculate total transmission power according to the total network size.
2. Energy efficiency nodes are find out
3. Finding the energy efficiency node in the overall network.
4. Transmission power can be transmitted only in the energy efficient nodes.
5. Among the 10nodes only 4 nodes are participated in the communication.

I. Load Power Control Architecture

According to Fig. 6, The Load power domain is running in the network layer. Each node in the network find out the individual power level, when the transmission takes place, each node assigns its individual power according to the network traffic. The transmission power is set for the data packets and the power level is changed for every individual packet in the network. In the network layer, the power route module consists of DEST, NEXTHOP, METRIC and TXPOWER. In this Cross-layer deals with physical to transport layer. All the informations are shared between these four layers. LOADPOWER agent runs the routing domain from R_S to R_d. Transport layer set the TXpower to broadcast the packets. It reduces the overall end-end delay and increase the network lifetime.

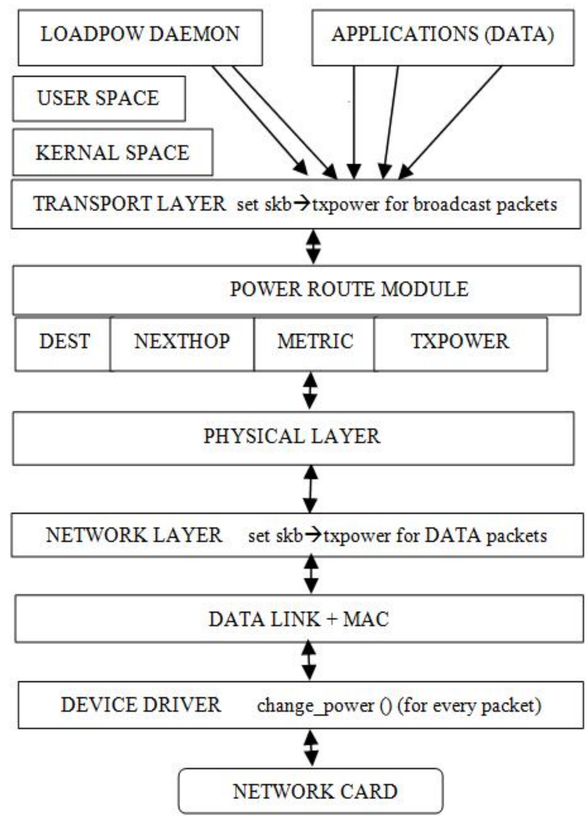

Figure 6. LoadPower Architecture

The Software architecture diagram of LOADPOWER architecture shows that the network layer power control has a impact on POWERROUTE. The source node should send the source id and the power level (PL_i) to the neighboring nodes in the network. When the power level is assigns to all nodes in the network, and then it starts the routing. In this LOADPOWER architecture, only the energy efficient nodes only taken into consideration for routing. Tramsmission power is high, when compared to the received power in the overall network. Performance parameters for LOADPOW protocol is mainly end-end delay, throughput and the energy consumption.

IV. Results and Discussion

The simulation of the LOADPOW Protocol is based on the network load. When the load is low, high transmission is

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to be given. Initializing 14 nodes in the network and the communications take place between the nodes. First finding the nodes having the energy efficiency. Energy efficiency is that the power levels lies between 4mw-5mw then it chooses the nodes. When the nodes does not having the energy efficiency it drops the packet and chooses another node for communication. Our goal is to reduce the end-to-end delay, increase the throughput and minimizes the energy.

Asymmetric routing occurs when the path from node n1 to node n2 is different from the path from n2 to n1. The following shows a simple topology, and cost configuration that can achieve such a result: Nodes n1 and n2 use different paths to reach each other. All other pairs of nodes use symmetric paths to reach each other.

```
$ns cost $n1 $r1 2
$ns cost $n2 $r2 2
$ns cost $r1 $n2 3
```

Any routing protocol that uses link costs as the metric can observe such asymmetric routing if the link costs are appropriately configured.

TABLE I. SIMULATION PARAMETERS

Parameters	Settings
channel type	Channel/Wireless Channel
radio-propagation model	Propagation/TwoRayGround
Antenna type	Antenna/Omni Antenna
Link layer type	LL
Interface queue type	Queue/DropTail/PriQueue
max packet in ifq	250
network interface type	Phy/WirelessPhy
MAC type	Mac/802_11
number of mobile nodes	20
routing protocol	AODV
battery model	Battery/Simple
generic radio hardware	Radio/Simple

Table I, shows the parameters and the settings for the simulation environment in ns-2 simulator. Parameters are channel type, radio propogation model, antenna type and so on. In this simulator 14 nodes are participating and AODV routing protocol are used for routing for LOADPOW protocol.

A. Comparison of Throughput for Four Protocols

A measure of the amount of data transferred in a specific amount of time, usually expressed as bits per second (bps) is called as throughput. The amount of data moved successfully from one place to another in a given time period.

B. Effect of Time and Number of Packets

According to Fig. 7, throughputs vary for all the protocols. LOADPOW throughput is increasing than the other protocols. Due to energy efficiency, transmission avoids the packet drop and reaches the destination within the specified time period. So throughput is increasing, while compare with other protocols like COMPOW, CLUSTERPOW and MINPOW it mainly decrease the throughput because fixing of power values are varying for all the nodes. Due to this time period is different for other protocols.

COMPOW and CLUSTERPOW are mainly uses the lower power level. MINPOW is only maximizing the energy consumption in the network. Throughput curve is linear for LOADPOW and MINPOW due to signal strength of the network. COMPOW and CLUSTERPOW are using the lower power value. At 90th second throughput is increased for LOADPOW protocol. The COMPOW and CLUSTERPOW protocol is not linear because, power level is given at the transmission of each node. Both protocols linear at 0-20 seconds and nonlinear between 30-80 seconds.

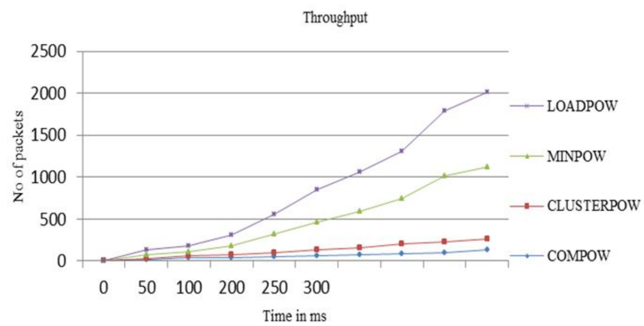

Figure 7. Throughputs for Four Protocols

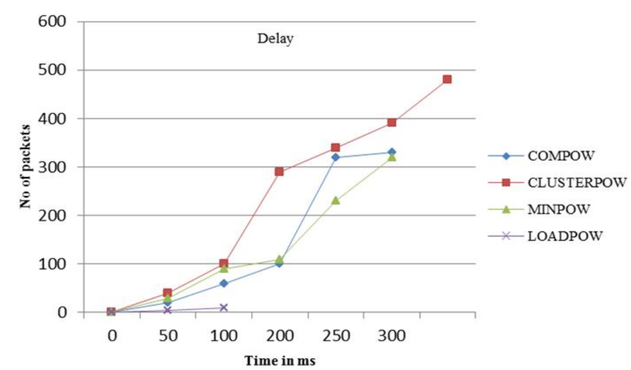

Figure 8. Delays for Four Protocols

C. Comparison of Delay for Four Protocols

The amount of actual user data transmitted per second without the overhead of protocol information such as start/stop bits or frame headers and trailers is called as delay.

D. Effect of Time and Number of Packets

According to the Fig. 8, a delay varies for all protocols in which LOADPOW Protocol reduces the end-to-end delay. LOADPOW protocol initializes the transmission power based on the network load. Transmission takes place only the energy efficient nodes. So, the nodes having higher energy efficiency take part in transmission and reduce the delay. The COMPOW, CLUSTERPOW, MINPOW Protocols having higher end-to-end delay due to the network capacity. Delay reduces based on the network and the traffic carrying capacity. In LOADPOW it maintains the traffic so the delay is reduced. At 20-200 second delay is saturated at particular time 0 second in LOADPOW. Other protocols increasing the delay with respect to number of packets in the network.

E. Comparison of Power Consumption for Four Protocols

Power Consumption is defined as that amount of power consumed by the nodes during transmission. It is denoted by mw.

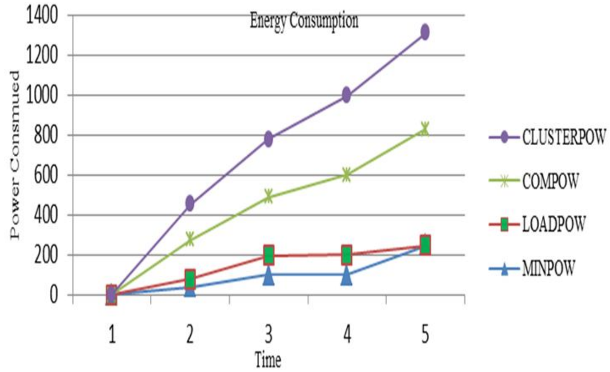

Figure 9. Energy Consumption for Four Protocols

F. *Effect of Time and Power*

According to the Fig. 9, the energy consumptions is minimum to LOADPOW than the other Protocols due to energy efficiency of the nodes. In LOADPOW initial transmission is higher based on network load. Transmission takes place by energy efficiency; the route selects only the efficient path. So the initial transmission power is increases but the receiving transmission power is reduced. Based on these results LOADPOW reduces the energy consumption than the other protocols. In COMPOW protocol chooses only the lower power level, it increases the energy efficiency. In CLUSTERPOW protocol increases the network capacity and it also uses the low transmission power for communication. In MINPOW, each node uses the own transmission power, so it reduces the energy consumption. At 200th second power consumption is 100mw is minimized in LOADPOW Protocol but the other protocols are using the highest power of 300mw for transmission.

G.. *Throughput, Delay for LOADPOW Protocol LOADPOW Throughput - Time (Vs) Number of Packets*

In Fig. 10, LOADPOW Protocol throughput for varies for source and destination. In our simulation, considering 3 sources and destination. Based on the source. and destination throughput differs in throughput. First and source and destination increases the throughput based on transmission power and Asymmetric routes. But the final source and destination decreases the throughput due to lower transmission power. But the overall throughput is increasing in LOADPOW Protocol.

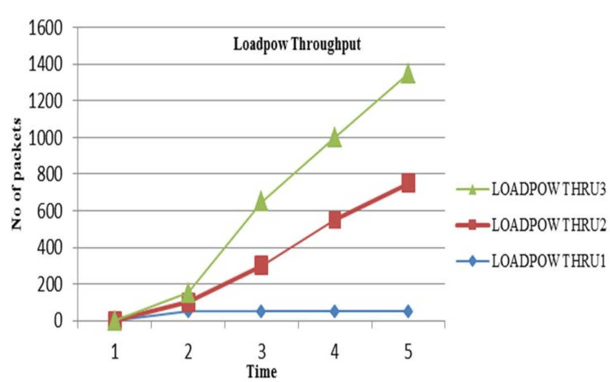

Figure 10. LOADPOW Throughput

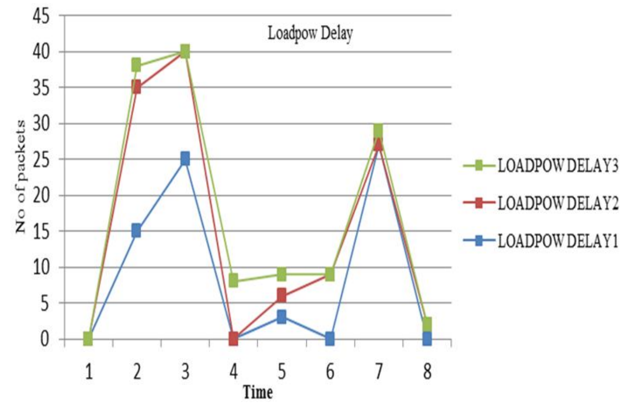

Figure 11. LOADPOW Delay

H. *LOADPOW Delay – Time (Vs) Number of Packets*

In Fig. 11, LOADPOW Delay considering 3 sources and destinations. Delay varies for various source and destination. Delay varies according to transmission power. In LOADPOW it uses the independent power, but first source and destination increases the delay and the second and third decreases the delay. So the overall delay is reduces the end to end delay in the network.

V. Simulation Environment

In Fig. 12, shows LOADPOW power control protocol simulation based on the network load, transmission power is to be given. When the network load is low, high transmission power is given. It distributes the transmission power to all the nodes. Each node selects its own power level because it is asymmetric routes. In our simulation, we used 14 nodes for the transmission. The power level is denoted by mw (milli watts). Less mw is taken for the overall transmission to reduce the power level. So the node selects the very low power level according to the packet size.

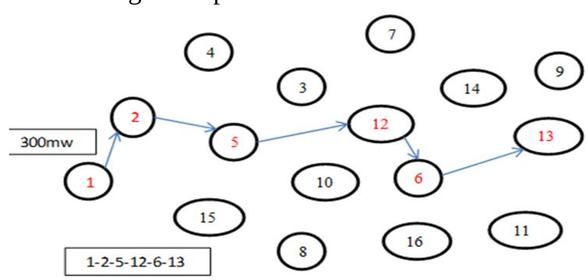

Figure 12. Simulation of Transmission power

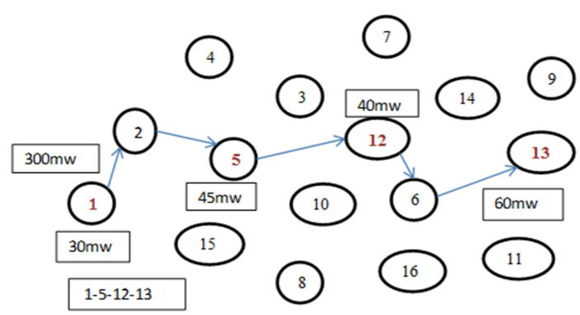

Figure 13. Finding Energy efficient nodes

In Fig. 13, shows that finding the energy efficient nodes. Power level is fixed for energy efficiency. During transmission, route selects the path only the nodes having energy efficiency. It uses the AODV routing protocol. In NAM 1 is the source and 13 is the destination, red color number indicates that nodes having energy efficiency and black colornumber indicates that nodes hot having energy efficiency.

In Fig. 14, asymmetric routes are communicated in LOADPOW. Independent power control algorithm is used for transmission. When the node is not energy efficiency it selects the other node for communication. 1 is the source and 13 is the destination. Three source and destination are given in LOADPOW protocol. By considering energy efficiency, it reduces the end to end delay, increases the throughput and minimizes the energy consumption. The higher transmission power is given during transmission and lower power is received at the receiver. So LOADPOW power control protocol is reduces the power level efficiently than the other three protocols.

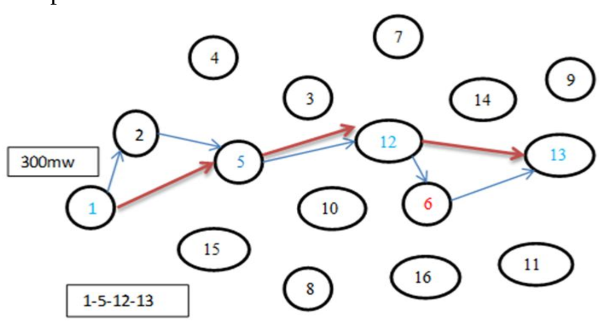

Figure 14. Asymmetric routes in communication

In Fig. 15, all the energy efficient nodes are communicated and the powers also distributed. The nodes having more threshold value only take part in the communication. The simulation setup may be vary according to the routing protocols. In this simulation LOADPOW used AODV routing and all other power control method uses the different routing protocol. In MINPOW, DSDV routing protocol is used.

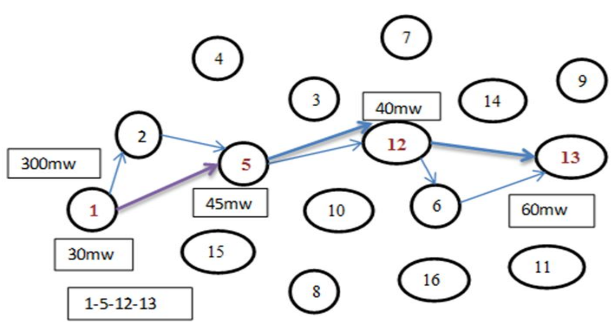

Figure 15. Communicated nodes

VI. Conclusions

Power control is a prototypical example of a cross-layer design problem. We identified the impact of power control on a variety of parameters and phenomenon, and then presented fundamental design principles. We then developed protocols guided by these principles, taking into account architectural considerations for implementing them in an actual system. Some of the protocols have been implemented and tested been implemented and tested. Perhaps, the holistic approach used here may be useful in other such context.

In future, we can implement several power control protocols considering the load balancing with power consumption. Depends on protocols the power control is to be reduced. The main consideration is the performance metrics like throughput, delay and energy consumption. Power control is often considered a problem belonging completely at the MAC layer, thus MAC protocols dealing with power control have been proposed. Implementing power control in MAC layer is tedious. In future work MAC layers plays main role in the power control protocols. MAC layer in power control plays a local optimization but network layer plays a global optimization. But MAC layer power is a symmetric in nature. Changing of power is difficult in MAC layer.

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References

[1] Nuraj L. Pradhan *, Tarek SaadawPower control algorithms for mobile ad hoc networks in Electrical Engineering Department, The City College of the City University of New York, 160 Convent Avenue,New York, NY 10031, USAReceived 29 November 2010; revised 19 April 2011; accepted 22 April 2011

[2] T. S. Rappaport, A. Annamali, R. M. Buehrer, and W. H. Tranter, "Wireless Communications: Past events and a future perspective," IEEE Communications Magazine, pp. 148-161, May 2002.

[3] S.-J. Park and R. Sivakumar, "Load sensitive transmission power control in wireless ad-hoc networks," in Proceedings of IEEE GLOBECOM, pp. 42-46, 2002.

[4] CW Tan , SK Bose . Modifying AODV for efficient power-aware routing in MANETs. In: TENCON 2005, Melbourne , p. 1–6. Australia2005.

[5] Lee SH, E Choi , DH Cho Timer-based broadcasting for power aware routing in power-controlled wireless ad hoc networks. Commun Lett , pp.222-4, 2005.

[6] Woo Kyungtae, Yu Chansu. Non-blocking localized routing algorithm for balanced energy consumption in mobile ad hoc networks. In: IEEE international workshop on modeling, analysis , and simulation of computer and tele communication systems2001, MASCOTS 2001, Ohio, pp.117 24,USA; 2001.

[7] S Narayanaswamy, V Kawadia , RS Sreenivas power control in ad hoc networks theory, architecture, algorithm and implementationof the COMPOW protocol. In: European wireless conference, Florence, pp. 156-62, Italy;2002.

[8] Kawadia Yikas, PR Kumar. Principles and protocols for power

control in wireless ad hoc networks. IEEE J Select Areas Communication 23(1):76–88, 2005.

[9] Bing Li, Zhigang Jin, Yantai Shu. Cross-layer design of energysaving AODV routing protocol. Trans Tianjin Univ15(5):343–9, 2009

[10] Bing Li, Zhigang Jin, Yantai Shu. CEMAODY: cross-layer designof energy-conserving multicast AODV routing protocol. In: 3rdinternational conference on communications and networking in China, ChinaCom 2008, Hangzhou, China; 2008. p. 743–47.

[11] Gomez Javier, Campbel Andrew T. PARO: supporting dynamic power controlled routing in wireless ad hoc networks, 9(5):443–60, 2003.

[12] J.-H. Chang and L. Tassiulas, "Energy conserving routing in wireless ad-hoc networks," Proceedings of the NineteenthAnnual Joint Conference of the IEEE Computer and Communications Societies (INFOCOM 2000), vol. 10.